Adriatic Circulation Experiment--Mesoscale Dynamics and Response to Strong Atmospheric Forcing

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LONG-TERM GOALS

This study contributes to our long-term efforts to understand:

- Processes governing exchanges between the shelf and deep ocean.
- The mesoscale dynamics of coastal waters.
- Processes that communicate atmospheric forcing to the ocean interior.

OBJECTIVES

We seek to understand the role played by three primary driving forces: (1) wintertime Bora winds, (2) weaker, along-basin Sirocco winds and (3) seasonal buoyancy input from the Po River and other sources, in governing the evolution of coastal filaments, eddies and fronts in the central and northern Adriatic.

APPROACH

Two cruises, planned for January/February 2003 and May/June 2003, will sample the central and northern Adriatic in winter, when strong Bora occur most frequently, and in spring, during the peak freshwater discharge. Both cruises will focus on understanding the dynamics of fronts, filaments and plumes, contrasting their response to dramatically different regimes of wind forcing, buoyancy input and ambient stratification. Sampling will center on repeated high-resolution, three-dimensional surveys conducted using our SeaSoar (and, if available, Triaxus) towed profiling vehicles. These sensor platforms profile from the surface to approximately 200 m (deeper for Triaxus) while being towed at speeds of up to 8 knots, providing depth-dependant along-track resolutions of 0.5-2 km with full-depth coverage in the northern and central Adriatic. In addition to redundant Seabird temperature and conductivity probes, the profiler will carry sensors measuring chlorophyll and CDOM fluorescence, light transmission, dissolved oxygen and 9-wavelength attenuation and absorption (Wetlabs AC-9, B. Jones, USC). We will also integrate an upward-looking 1.2 MHz RDI ADCP and a six-axis accelerometer, which will provide high-resolution shear measurements in the near-surface region that shipboard ADCPs cannot resolve. This will be important in the Adriatic and in other regions where we expect much of the variability associated with plumes and filaments may be tightly

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confined to the surface layer. Shipboard ADCP and GPS navigation will provide additional velocity and position information.

Both cruises will involve multiple science operations conducing physical, biological, optical and meteorological studies. Dr. H. Peters (RSMAS) will make turbulence measurements using a bottom-mounted, 5-beam ADCP, an experimental profiling CTD (provided by Dr. R. Pinkel, SIO) and a free-fall, vertical profiler (SWAMP). Dr. P. Poulain (OGS-Trieste) will conduct repeat drifter deployments. Dr. B. Jones (USC) plans to conduct optical measurements using a dedicated profiling package, and will take responsibility for the optical measurements made from the towed profiler. Dr. C. Dorman (SIO) will conduct meteorological measurements. Dr. D. Thaler (Austrian Army), with support from shore-based Croatian meteorologists, will provide short-term synoptic forecasts during the winter cruise. Drs. R. Arnone (NRL-SSC) and E. Mauri (OGS-Trieste) plan to conduct optical measurements and to operate a real-time shipboard remote sensing station, providing SeaWiFS and AVHRR imagery throughout the cruises. Dr. M. Marini (IRPEM-Ancona) will measure nutrients and pigment concentrations, while Drs. Villici (Univ. of Zagreb), Danovaro, Pusceddu and Dell'Anno (Univ. of Ancona) will conduct a wide range of phytoplankton studies. Additionally, Dr. P. Flament (UH) will provide near real time surface velocity maps constructed from his HF radar array.

We will use real-time remotely sensed maps of sea surface temperature, ocean color and surface velocities to select filaments and fronts for intensive surveys. Short-term meteorological forecasts will allow us to plan our sampling around the locations and times of strongest Bora forcing. Because Bora occur at short temporal (hours) and spatial (10 km) scales, both timing and location are critical. The combination of remote sensing (satellite and radar) and meteorological forecasts provides the information required to focus our measurement efforts on specific mesoscale features as they undergo strong Bora forcing. Sampling strategies will be modified in response to the presence of specific features and to the forecasted character of each event. For example, we might design a survey to sample a filament forecasted to experience strong Bora forcing. Just prior to the Bora onset, we would deploy moored instruments in the region of predicted maximum winds, followed by drifter releases upstream of the mooring site. We would then execute repeated three-dimensional synoptic surveys and cross-filament hydrographic/optical sections near the moorings through the course of the Bora. Afterwards drifters and moorings would be recovered and serviced in preparation for the next forcing event. Possible survey sites (Figure 1) include filaments extending from the Croatian coast, the strong, potentially unstable, East Adriatic Current and the Po river plume.

WORK COMPLETED

During this first year, efforts have focused on building scientific collaborations, gathering historical data (for the construction of a climatology, in conjunction with ONR grant N00014-02-1-0135) and preparing our towed profiler for the January field program. As detailed above, several science teams have elected to participate in the two towed profiling cruises, augmenting our original measurement program with an extensive suite of biological and optical measurements and providing critical real-time remote sensing and meteorological forecasting capabilities. We are coordinating our efforts with Dr. Mirko Orlic (Univ. of Zagreb) and Dr. Anello Russo (Univ. of Ancona and IPREM-Ancona), two physical oceanographers who have worked extensively in the Adriatic and who have ongoing measurement programs. Drs. Orlic and Russo will collaborate on scientific analysis and will participate in the cruises. Our measurement program and subsequent analysis will also be coordinated

with investigations taking place as part of the Adriatic Circulation Experiment (ACE, and NRL-SACLANCEN Joint Research Program) and the EUROSTRATAFORM project.

Marlene Jeffries, a University of Washington graduate student working on this project, has compiled archived hydrographic data from a wide range of sources, including the Mediterranean Online Database, the National Ocean Data Center, the OGS-Trieste archives and the data holdings of IPREM-Ancona. Ms. Jeffries is using this data, along with historical meteorological and river runoff records, to construct a climatology of the northern and central Adriatic. We will use these use results to refine our sampling and to provide context for the subsequent scientific analysis. The climatology project will lead Ms. Jeffries into a detailed analysis of the surveys collected during the two cruises, from which she will draw her doctoral dissertation.

Through 2002 we have been working with the Danish ocean technology firm MacArtney A/S to bring their new towed profiling vehicle (Triaxus) on-line for our mesoscale dynamics/ocean optics experiment in the northern and central Adriatic. This vehicle provides new capabilities that will greatly enhance our ability to synoptically sample the energetic, three-dimensional meso- and small-scale variability that dominates nearshore and coastal environments. Among the important innovations are: (1) lateral control, allowing us to sample outside the towing vessel's wake, (2) the ability to profile efficiently at a wide range of tow speeds, (3) high-bandwidth, fiber optic telemetry with interfaces designed to ease the integration of new payloads and (4) the ability to profile to depths of ~300 m on an unfaired cable. The combination of bare-cable operation (allowing the use of modest sized winches), flexible tow speed requirements and simple sensor integration provides an easy to operate, cost-efficient platform that can be deployed from a wide range of towing platforms.

Unfortunately, MacArtney has experienced severe fabrication quality problems with the subcontractor responsible for the vehicle's carbon fiber hull. Rather than deliver a fatally flawed product, they have redesigned the hull and switched fabricators to a high-end German carbon fiber shop. Delays associated with these changes have pushed delivery dates into early 2003 (compared to the originally specified May 2002), making it impossible to use Triaxus for our January 2003 Adriatic cruise. Anticipating the possibility of a late delivery, we had already formulated plans to resurrect our old, inoperable SeaSoar. To enhance functionality over 'stock' SeaSoar systems and to facilitate cost-efficient maintenance and stocking of spares, our plans maximize the number of components shared between our new Triaxus and our rebuilt SeaSoar (now dubbed Trisoarus). The resulting vehicle will share nearly all of its components with Triaxus, including topside electronics (telemetry, power, control and data acquisition), cable, terminations, wing actuation motors and all subsurface electronics). To improve performance, we are integrating large-area, symmetric wings and an improved aileron system, both designed at CSIRO in Tasmania. Thus, with the exception of lateral flight control, Trisoarus will possess most of the advantages enjoyed by Triaxus. The two systems are complementary--Triaxus provides lateral control and adaptability to a wider range of towing speeds while SeaSoar remains better at handling over-sized sensor packages. In the long term, we will be able to choose platforms based on mission requirements, carrying the second vehicle as a drop-in, fully compatible spare. Both will provide new, enhanced capabilities for three-dimensional characterization of physical, optical and acoustical variability at small- and meso-scales.

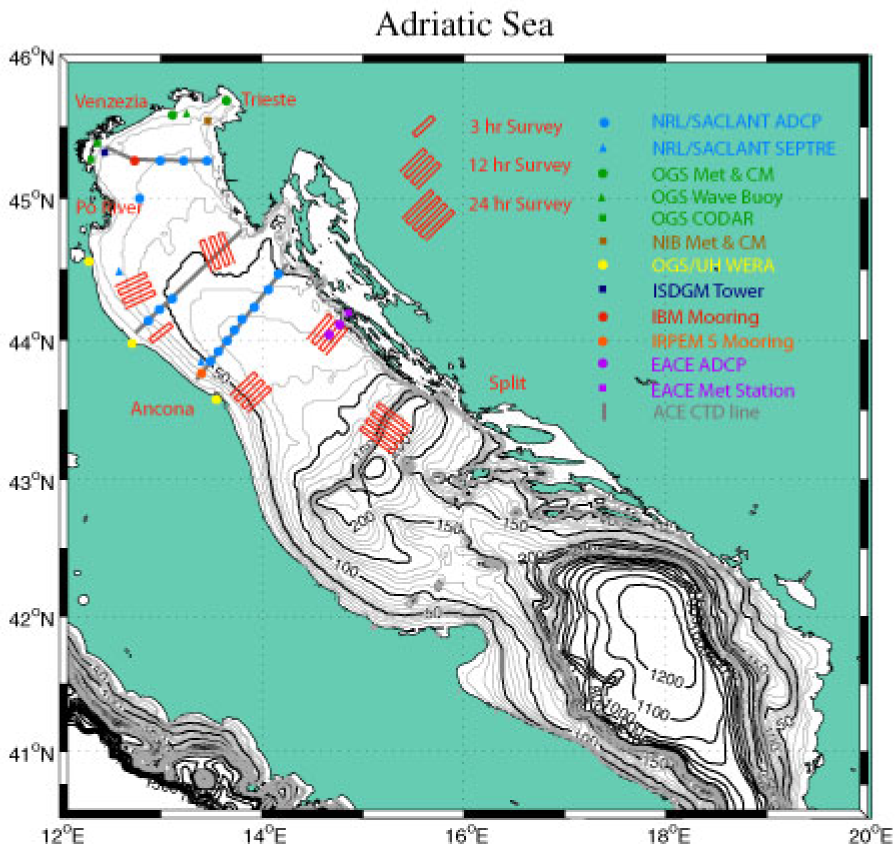

Figure 1. Sample survey patterns (red lines) requiring 3, 12 and 24 hours to complete. Additional symbols mark the locations of other observational resources that will be active during the January/February and May/June cruises.

RESULTS

No significant science results during the first year.

IMPACT/APPLICATION

The SeaSoar refurbishment and enhancement effort will produce a flexible new platform for making synoptic measurements in both nearshore and open-ocean environments. This system will complement out new Triaxus system, with each platform providing distinct capabilities while also acting as drop-in backup vehicles for each other.

TRANSITIONS

None.

RELATED PROJECTS

Optical Dynamics in the Adriatic Sea: The Role of River Plumes, Filaments and Fronts in the Distribution, Advection and Transformation of Inherent and Apparent Optical Properties, B. Jones (USC).

Adriatic Winter Meteorology and Bora Effects, C. Dorman (SIO and SDSU).

Adriatic Mesoscale Experiment, P. Poulain (NPSG and OGS- Trieste).

Mesoscale Dynamics of the Adriatic Sea, B. Cushman-Roisin (Dartmouth).

East Adriatic Coastal Experiment (EACE), M. Orlic (Univ. of Zagreb).

Adriatic Mesoscale Experiment: Surface Velocity Maps using HF Radar, P. Flament (UH).

The Adriatic Circulation Experiment, H, Perkins (NRL-Stennis), J. Miller (NRL- Stennis) and R. Signell (SACLANTCEN).

PUBLICATIONS

None.